Obstructed Sprinkler Piping
A Ticking Time Bomb

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Outline

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Purpose

- Provide information on the importance of obstruction investigations to the operability of automatic sprinkler systems
- Provide a real world example of the failure of a sprinkler system due to obstructed sprinkler piping, and the resulting large loss fire

Description of the Problem

- For sprinklers to be effective, there must be an unobstructed flow of water
- Clearly sprinklers are very effective, BUT, there have been numerous instances of impaired sprinkler efficiency because the sprinkler piping or sprinklers were plugged (NFPA 25, Appendix D), with
    - pipe scale
    - stones
    - Mud
    - corrosion products
    - other foreign material
- When sprinklers open, the obstructive material is broken loose, carried along the pipe, then plugging some of the sprinklers or forming obstructions at the fittings

Common Sources of Obstruction

Pipe Scale

- Involved in the majority of the obstructed sprinkler fire losses
- Dry pipe systems that have been maintained wet and then dry alternately over a period of years are particularly susceptible
- Dry pipe systems that are continuously dry are also vulnerable due to condensate in the air, which generally occurs at the bottom of the pipe

Photos courtesy of Jeffery Moore, Hughes Associates, Inc.

Careless Installation or Repair

- Wood
- Paint brushes
- Buckets
- Gravel
- Sand
- Gloves
- Cutout discs/coupons

Photos courtesy of
Jeffery Moore,
Hughes Associates, Inc.

Raw Water Sources

- Material sucked up from the bottom of rivers, ponds or open reservoirs by fire pumps with poorly arranged or inadequately screened or maintained intakes
  - o Rust
  - o Mud
  - o Stones
  - o Cinders

Photo courtesy of Jeffery Moore, Hughes Associates, Inc.

Biological Growth

- Asiatic clam (raw river or lake water)
  - Grow 9 mm to 11 mm in 1 year and up to 54 mm in 6 years
  - Enter sprinkler piping in the larval stage or while still small, then feed on the bacteria or algae
  - Brought to the United States (Washington State) from Asia in the 1930’s, now throughout at least 33 states
  - Highly infested areas include the Ohio River, Tennessee River Valley, Savannah River, Altamaha River, Columbia River, and Delta-Mendota Canal

Photo courtesy of Jeffery Moore, Hughes Associates, Inc.

Calcium Carbonate Deposits

- Natural fresh waters contain dissolved calcium and magnesium salts
- If the concentrations are high the water is considered "hard"
- The ability of $CsCO_3$ to precipitate on the metal pipe surface depends on the water's total acidity or alkalinity, and the concentration of dissolved solids in the water

Calcium Carbonate Deposits

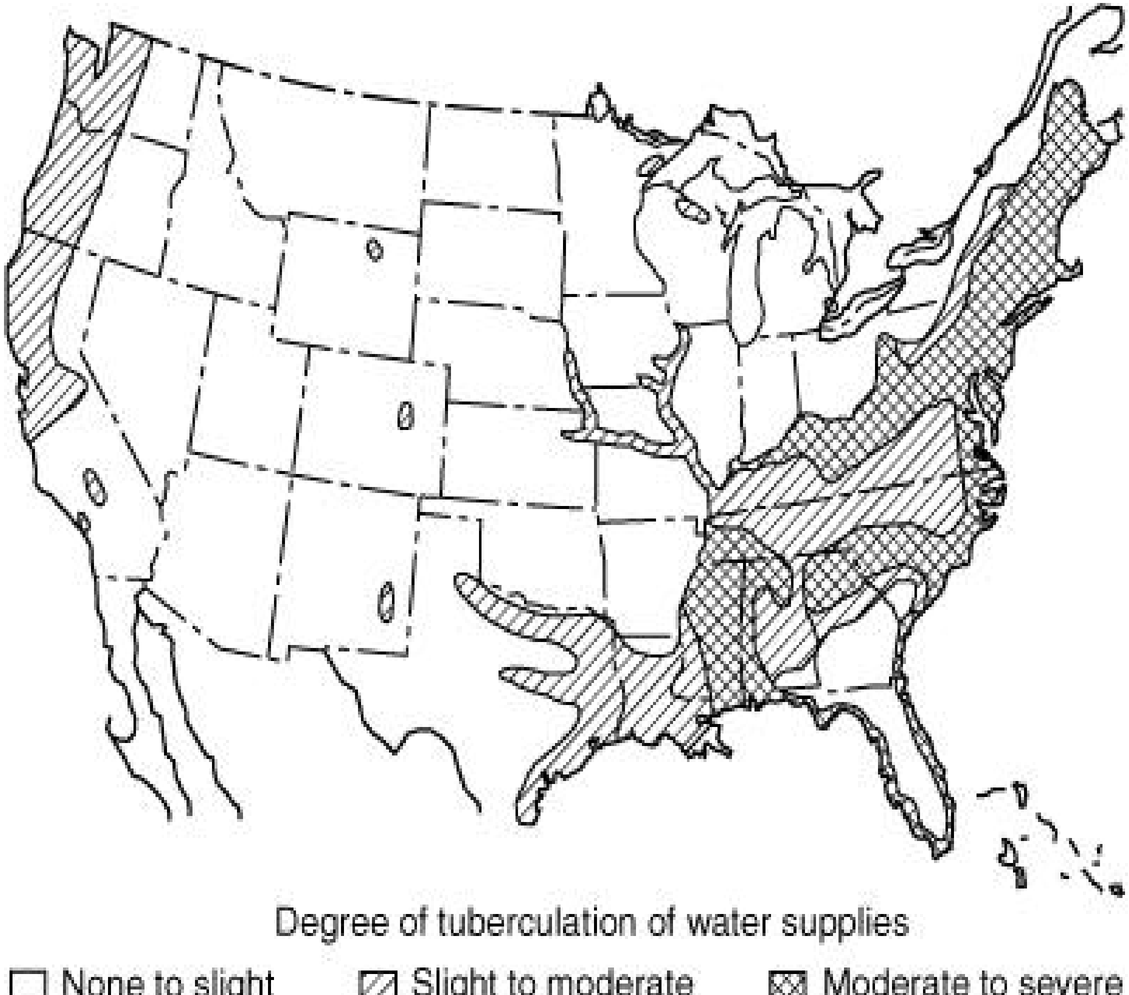
- In sprinkler systems the calcium carbonate scale tends to occur on the more noble metals (copper)
- Consequently scale formation naturally forms on sprinklers, often plugging the orifice
- This type of obstruction cannot be detected or corrected by normal flushing and can only be found by inspection/replacement of the sprinklers in suspected areas

Courtesy of Jeffery Moore, Hughes Associates, Inc.

Calcium Carbonate Deposits

- Most public utilities in very hard water areas soften their water, thus the most likely locations for deposits are where sprinklers are not connected to the public utility (wells, etc).
- Hard water areas include the Mississippi basin west of the Mississippi River and North of the Ohio River, the rivers of Texas and the Colorado basin.

Map of Hard Water Areas



Courtesy of NFPA 25, Appendix D, Figure D.2.5(a)

Calcium Carbonate Deposits

- Areas most likely to have deposits are
  - In wet pipe sprinkler systems only
  - In high temperature areas (near dryers, ovens skylights), except where water has unusually high pH.
  - Old sprinkler systems that are frequently drained and refilled
  - In pendent sprinklers that are located away from air pockets and near convection currents

Microbiologically Influenced Corrosion (MIC)

- Most common biological growths are formed by microorganisms, including bacteria and fungi
- These microbes produce colonies (biofilm, slimes) containing a variety of microbobes
- These colonies form on the surface of wetted pipe in both wet and dry systems and deposit iron, manganese and various salts onto the pipe surface

Photo courtesy of Jeffery Moore, Hughes Associates, Inc.

Microbiologically Influenced Corrosion (MIC)

- These discreted deposits* cause obstruction to water flow and can also dislodge causing plugging of fire sprinkler components
- Subsequent under-deposit pitting can also result in pinhole leaks

* termed nodules, tubercles and carbuncles

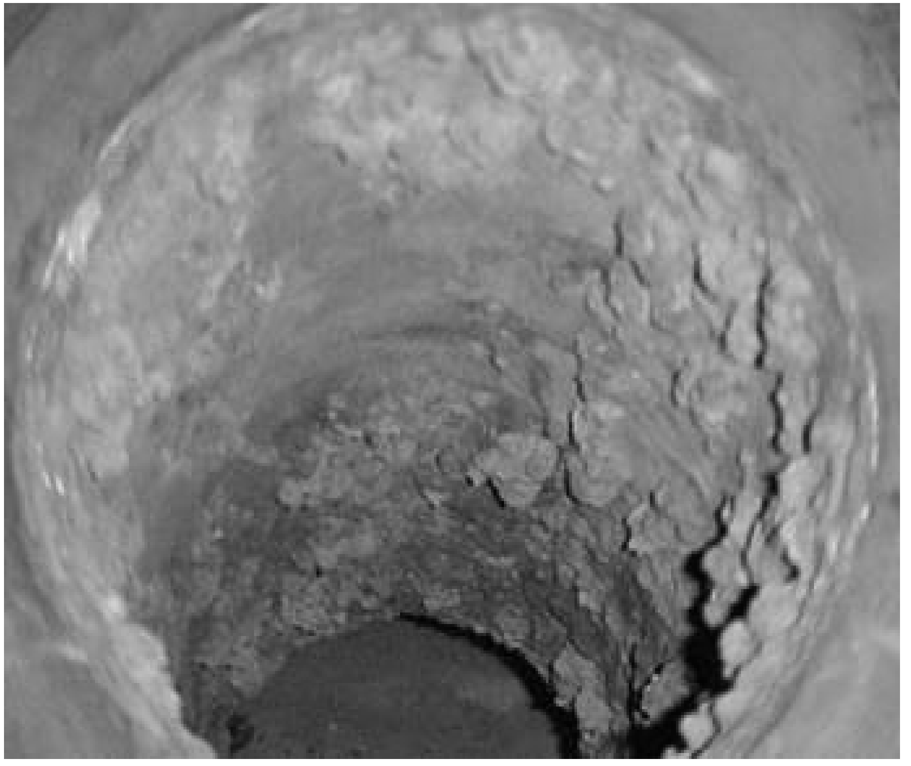


Photo courtesy of Jeffery Moore, Hughes Associates, Inc.

Microbiologically Influenced Corrosion (MIC)

- MIC is corrosion influenced by the presence of and the activities of microorganisms
- It almost always occurs with other forms of corrosion
- MIC is most often seen as severe pitting

Microbiologically Influenced Corrosion (MIC)

- MIC is first noticed as a result of pinhole leaks after only months to a few years of service
- Initial tests for the presence of MIC should involve on-site testing for microbes and chemical species (iron, pH and oxygen)
- Samples are easily taken from the inspectors test connection and/or main drain

Courtesy of American Fire Sprinkler Association

Microbiologically Influenced Corrosion (MIC), continued

- The occurrence and severity of MIC is enhanced by
  - Using untreated water
  - Introduction of new and untreated water containing oxygen, microbes, salts and nutrients
  - Leaving dirt, debris, pipe joint compound, and especially oils in the piping, which all provide nutrients for microbiological growth

Obstruction Investigation

- Per NFPA 25, Section 13.2.1 “An investigation of piping and branch line conditions shall be conducted every five years by opening a flushing connection at the end of one main and by removing a sprinkler toward the end of one branch line for the purpose of investigating for the presence of foreign organic and inorganic material”

Obstruction Investigation

- Per NFPA 25, Section 13.2.1.1, Alternative nondestructive examination methods are permitted
  - Ultrasonic
  - X-ray
- Per NFPA 25, Section 13.2.1.2, Nodules or slime, if found shall be tested for MIC.

Additional Criteria to Perform an Obstruction Investigation

- Defective intake for fire pumps taking suction from open bodies of water
- Discharge of materials during routine testing
- Foreign materials in pumps, valves, etc.
- Foreign material in water during drain tests or plugging of inspectors test connection
- Plugging of sprinklers
- Plugged sprinkler piping found during renovations
- Failure to flush yard piping after new installations or repairs
- Broken public mains in the vicinity
- Reduced flows during routine underground testing (loop tests)

Additional Criteria to Perform an Obstruction Investigation

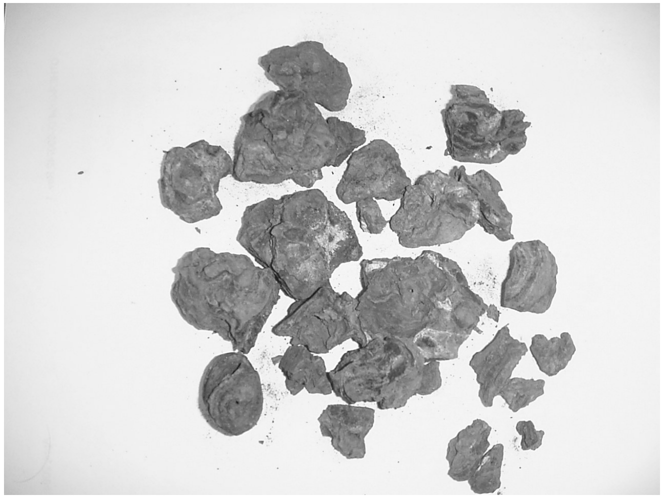
- Abnormally frequent false tripping of dry pipe valves
- A system that is returned to service after more than 1 year of isolation
- A reason to believe that the system contains sodium silicate
- Pinhole leaks
- A system that at some point was supplied by raw water via the fire department connection
- A 50% increase in the time it takes water to travel to the ITC during full flow DPV trip tests when compared to the acceptance tests

Investigation Procedures

Investigate Yard Mains First

- Flow through yard hydrants, preferably near the extremes
- Use burlap bags to catch debris
- If obstructive material is found, all mains should be flushed

Photo above courtesy of Joseph G. Pollard Company



Investigating Sprinkler Systems

- Investigate dry systems first, representative systems are usually sufficient
- If obstructive material is found, investigate all of the systems
- System can be considered ok if
    - Less than ½ cup of scale is washed from the cross mains
    - Scale fragments are not large enough to plug a sprinkler orifice
    - A full, unobstructed flow is obtained from each branchline

Investigating Sprinkler Systems

- When selecting systems or branch lines for investigation, consider lines found obstructed during a fire (in reality this must be done immediately after discovery) and/or systems adjacent to points of recent repair to yard mains
- Tests should include flows through a 2 ½ inch fire hose directly from cross mains and flows through 1 ½ inch fire hose for branch lines
- Two or three branch lines is considered representative for each sprinkler system

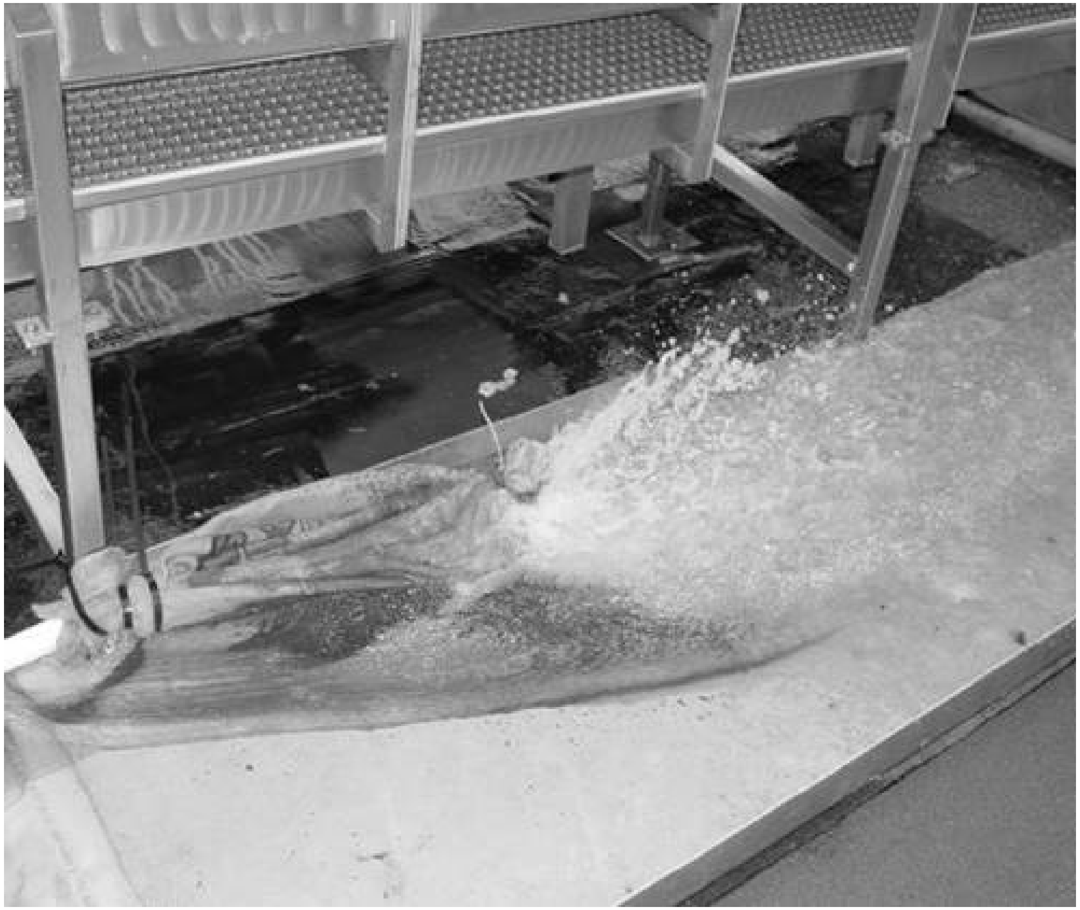
Investigating Sprinkler Systems

- Fire pumps should be used to ensure sufficiently large flows
- Burlap bags should be used to collect dislodged material
- Each flow should be continued until the water clears (absolute minimum of 2 of 3 minutes)

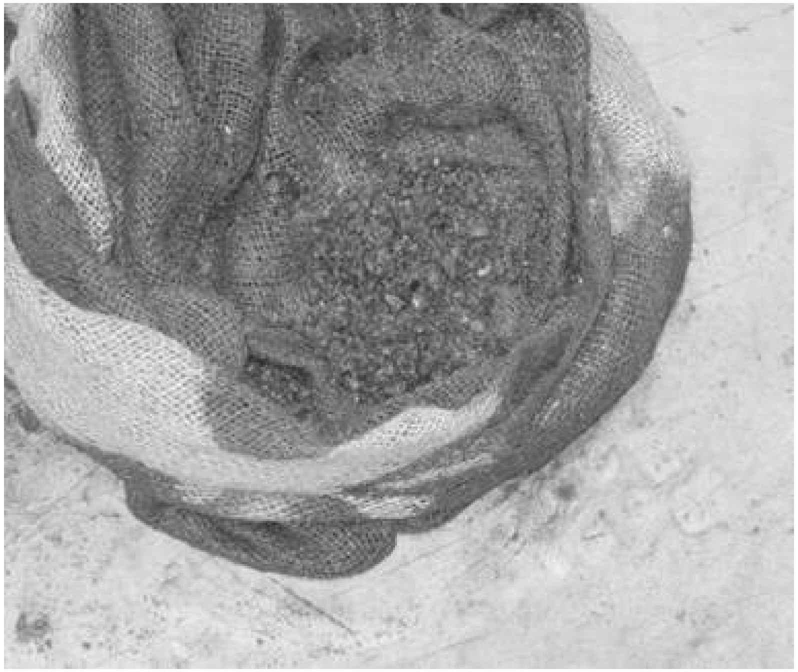
Courtesy of Flo-Pak, Inc

Investigation Procedures

Flushing Of Branchline with 1½ Fire Hose and Burlap Bag



Debris from Flushing Investigation*

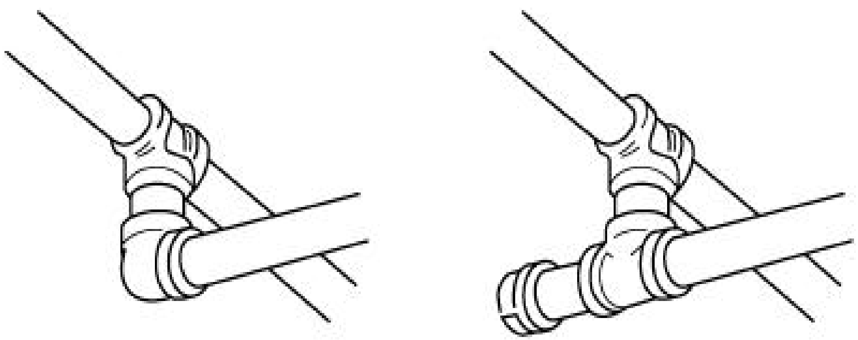


*greater than 1/2 cup

Sprinkler Systems

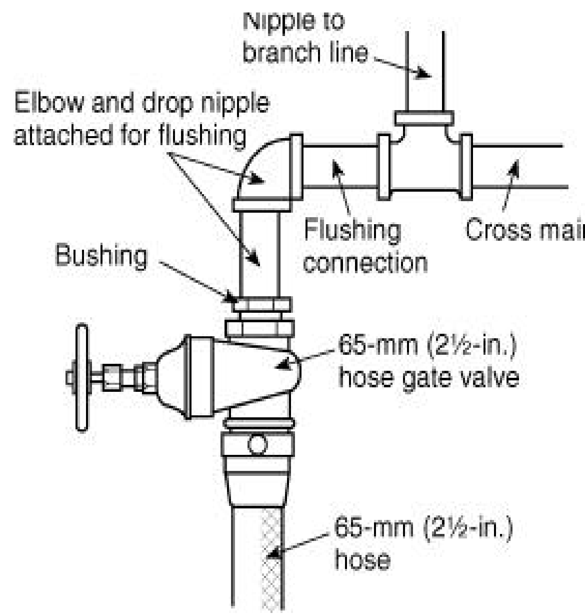
- Dry pipe systems should be flooded (made wet) one or two days prior to the examination (make sure to initiate compensatory measures due to the isolation of the sprinkler flow alarm)
- Restore the system and then trip the system as a simulation of normal action and flow the water through the 1 ½ inch hose lines into a burlap bag
- After the branch lines are examined and cleared, test the cross mains by discharging water through a 2 ½ inch fire hose and collect material in a burlap bag

Replacement of elbow at end of cross main with flushing connection consisting of a 2 inch nipple and cap



Courtesy of NFPA 25, Appendix D, Figure D.3.2(a)

Connection of 2½ inch hose gate valve with 2 inch bushing and elbow to 2 inch cross main



Courtesy of NFPA 25, Appendix D, Figure D.3.2(b)

Flushing Procedures

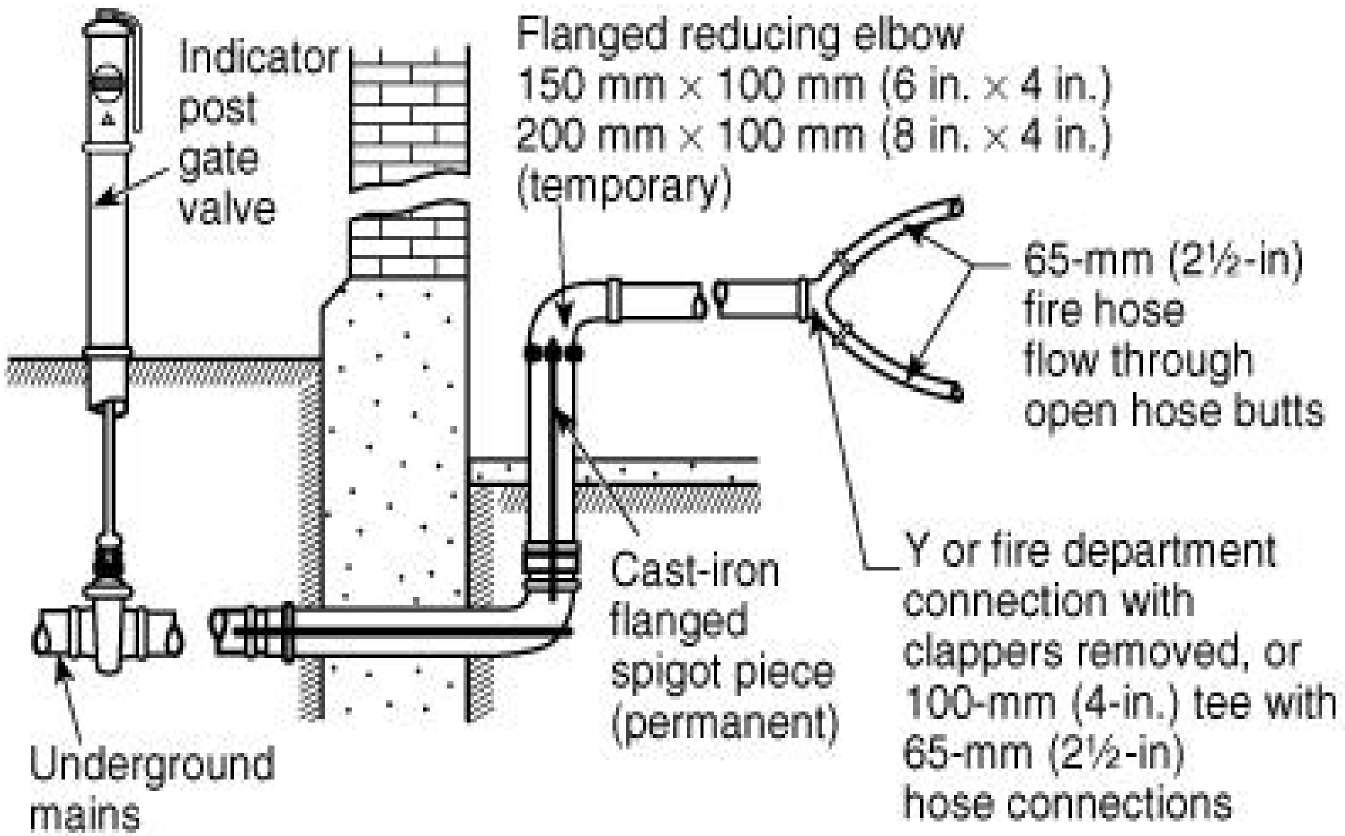
Yard Mains

- Yard mains should be thoroughly flushed before interior piping
- Flush at dead ends of the system or through blow-off valves
- Run water until clear (at least 2 to 5 minutes)
- If looped system, close divisional valves to produce a higher velocity flow through each single line

Yard Mains

- A velocity of at least 10 ft/sec is necessary to flush foreign material (see Table D.5.1 of NFPA 25 for the flow rate per pipe size to accomplish this velocity)
- Connections from the yard mains to sprinkler risers also need flushing (easy to forget)
  - 2 inch drain generally not sufficient
  - Can use FDC with clappers removed

Flushing of Lead-in



Courtesy of NFPA 25, Appendix D, Figure D.5.1

Sprinkler Piping

- Two methods
  - Hydraulic method
  - Hydropneumatic method
- Hydraulic Method
  - Flowing water from the yard mains ➔ sprinkler riser ➔ feed mains ➔ cross mains ➔ branch lines in the same direction as in a fire

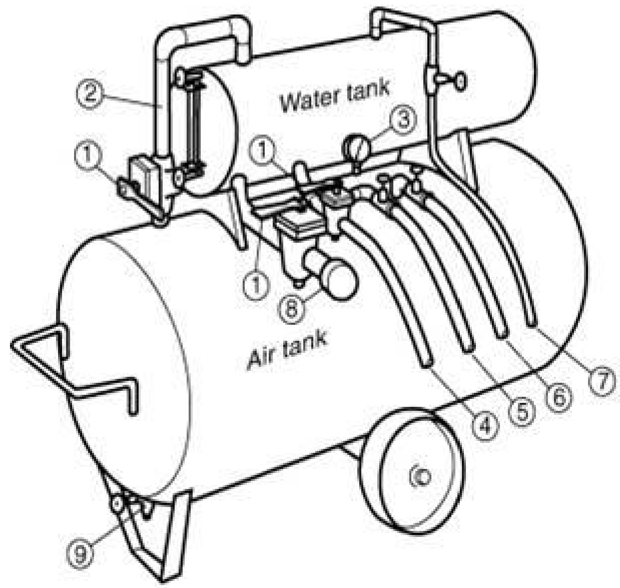
Sprinkler Piping

- Hydropneumatic method
  - Using special equipment and compressed air to blow a charge of about 30 gallons of water from the ends of the branch lines back to the feed mains and down the riser, washing material out of an opening at the base of the riser
- Sufficient velocity is required for both methods
- Pendent sprinklers should be removed and inspected at random locations until it is reasonably assured that they are free of obstructions

Sprinkler Piping

- Choice of method depends on conditions
  - If examination indicates the presence of loose sand, mud or moderate pipe scale the hydraulic method is generally effective
  - Where the material is more difficult to remove and available water pressures are too low, the hydropneumatic method is preferred
  - The hydropneumatic should not be used with CPVC piping

Hydropneumatic Machine



1 Lubricated plug cocks
2 Pipe connection between air and water tanks (This connection is open when flushing sprinkler system.)
3 Air pressure gauge
4 25-mm (1-in.) rubber hose (air type) (Used to flush sprinkler branch lines.)
5 Hose connected to source of water (Used to fill water tank.)
6 Hose connected to ample source of compressed air (Used to supply air tank.)
7 Water tank overflow hose
8 65-mm (2½-in.) pipe connection [Where flushing large interior piping, connect woven jacket fire hose here and close 25-mm (1-in.) plug cock hose connection (4) used for flushing sprinkler branch lines.]
9 Air tank drain valve

Courtesy of NFPA 25, Appendix D, Figure D.5.4(a)

Obstruction Prevention

Dry Pipe and Preaction Systems

- Those using noncoated ferrous piping should be investigated for obstruction from corrosion after 15 years, 25 years and every 5 years there after (in addition to flushing investigations)
- Those using noncoated ferrous piping should be left on air the year around
- Internally galvanized piping should be used for new systems. Fitting and couplings are not required to be galvanized.

Other Solutions to Mitigate the Problem

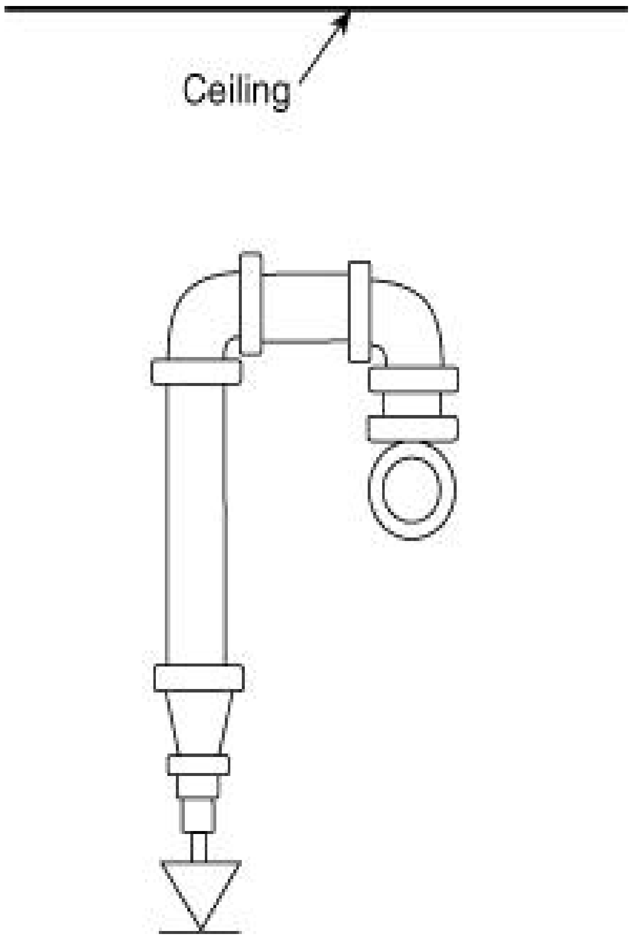
- "The New Galvanized Pipe"
- ASTM A653 zinc adhesion test
- Contact
  Curt Brown
  (815) 465-2102

Courtesy of IDOD Systems, Inc.

Flushing Connections

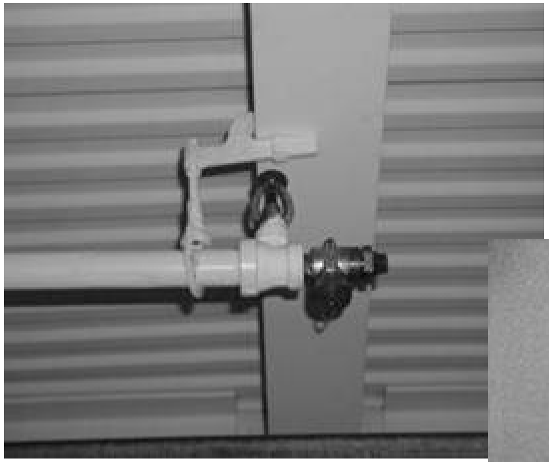
- NFPA 13 requires a flushing connection at each cross main (Section 8.14.16)
- Branch lines on gridded systems should be capable of being readily broken at a simple union or flexible joint
- NFPA 13 (Section 8.14.18) also requires the use of return bends to reduce the chances of debris dropping into the drop nipples. These are not required for deluge systems or dry pendant heads.

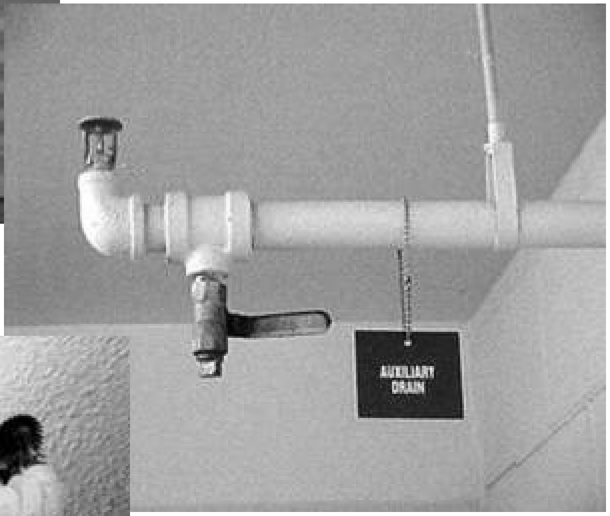
Return Bend



Courtesy of NFPA 13, Figure 8.14.18.2

Flushing Connections for Branchlines





All courtesy of Jeffery Moore, Hughes Associates, Inc.

Obstruction Prevention

- Screen pump suction supplies must be properly maintained (screen size criteria in NFPA 20)
- Asian Clams
  - To date, no effective method of total control has been found
- Calcium Carbonate
  - In hard water areas; a representative sample of sprinklers should be removed and inspected yearly
  - If deposits are found, replace those and adjacent sprinklers

Zebra Mussels

- Molluscides are effective, but very expensive
- Chlorination is best for short term treatment
    - There are strict EPA regulations
    - Could be devastating to the entire ecosystem
- Control measures should be applied at the water source, not within the piping system
    - Select a water source that is not subject to infestation
    - Implement water treatment including biocides, elevated pH
    - Implement water treatment that reduces O_2

Specific Code References

Subject	NFPA 25 Reference

Real World Example

- Mill plant in Lowell, MA
- Masonry, Plank on Timber construction, multi-story, single occupancy
- Fire protection water (suction source) was from a cannel near the facility
- Small fire and the initial sprinkler did not operate (fused but did not flow)
- The fire progressed with few or no sprinklers operating

Real World Example

- Fire Department affected final extinguishment
- Total loss well over $10M
- During post fire investigation, sprinkler piping was closely investigated and most if not all of the sprinkler piping was obstructed with a fibrous algae type of material

Real World Example

- Interviews revealed that the facility had not conducted flushing examinations

Real World Example

- During the investigation even the 2 1/2 inch cross mains were obstructed; thus a simple examination of the interior of the pipe would have revealed the extent of the obstruction

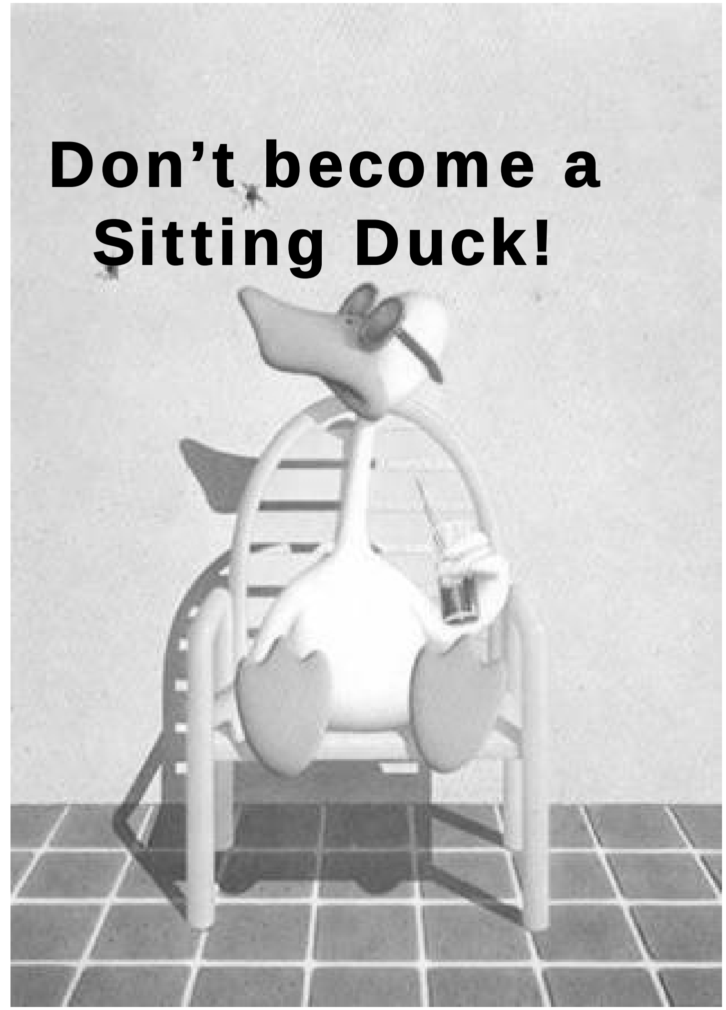

Both courtesy of Tommy Brown

Conclusions

- Obstruction Investigations are clearly required by NFPA 25 (Chapter 13),
- It’s not obvious that this is being accomplished on a frequent basis
- NFPA 25 provides clear criteria for flushing investigations and the flushing of systems (if warranted)
- Don’t let your in-place bright and shinny sprinkler system lull you into false security

Conclusions

- Establish a program now to perform the investigations
  - o Owners: Do it!
  - o AHJ: Enforce it!
  - o Consultants: Ask the right questions, provide the right advise
  - o Vendors: Push this important ITM function



Courtesy of Michael Bedard

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  Hughes Associates, Inc. (retired)

References

- NFPA 13, “Standard for the Installation of Sprinkler Systems”, 2002 Edition
- NFPA 25, “Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems”, 2002 Edition
- FPC/Fire Protection Contractor, November 2003; “Is it “MIC”, Richard O’Leary
- FPC/Fire Protection Contractor, November 2003; “The New Galvanized Pipe”, Curt Brown